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**Kaali**

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[54] **VISUALLY DIRECTED TROCAR AND METHOD**

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[58] Field of Search ..... **600/114, 104, 600/106, 117, 127, 183; 604/164, 165, 166, 167, 264, 272; 606/185**

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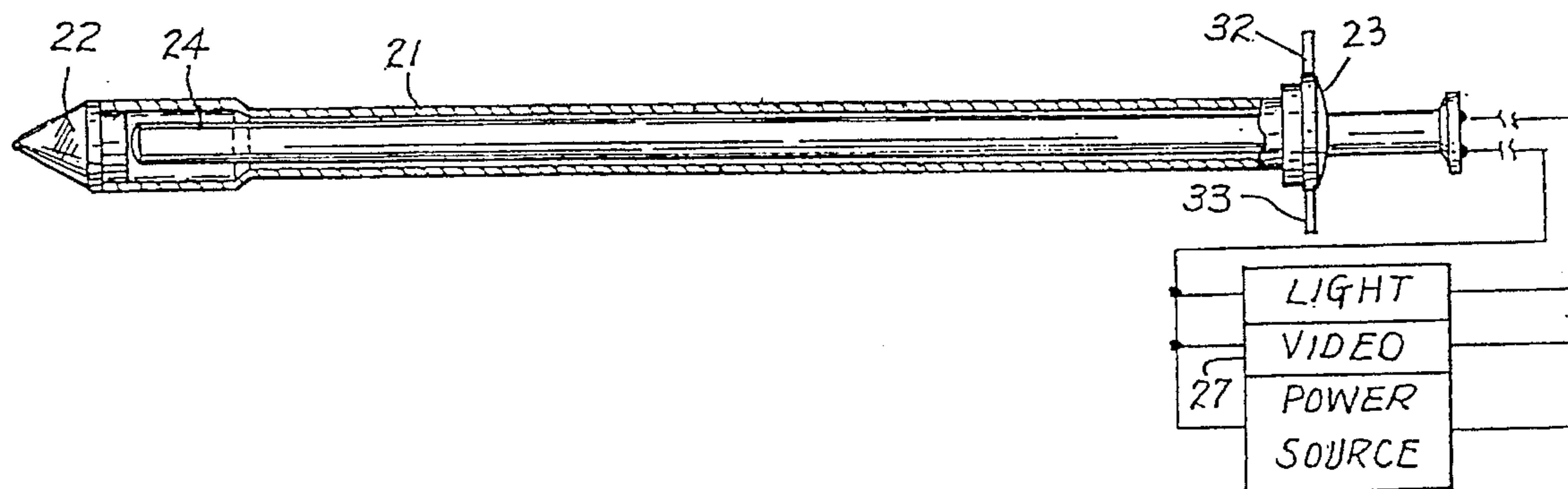
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### [57] ABSTRACT

A new and improved laparoscopic trocar and sleeve assembly in which the trocar is provided with a transparent tip and accommodates a light telescope for supplying a video console so that while the trocar is being surgically inserted through the abdominal wall and into the abdominal cavity, visualization on the video console will be possible to avoid injury to blood vessels in the abdominal cavity wall or injury to any of the internal organs located in the abdominal cavity. Once clear visualization is established, conventional laparoscopic procedures can be carried out safely.

**16 Claims, 2 Drawing Sheets**



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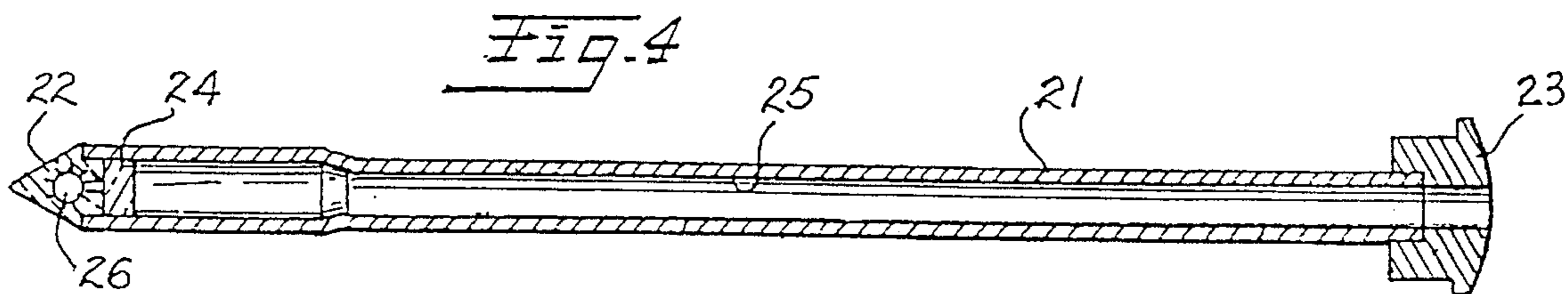
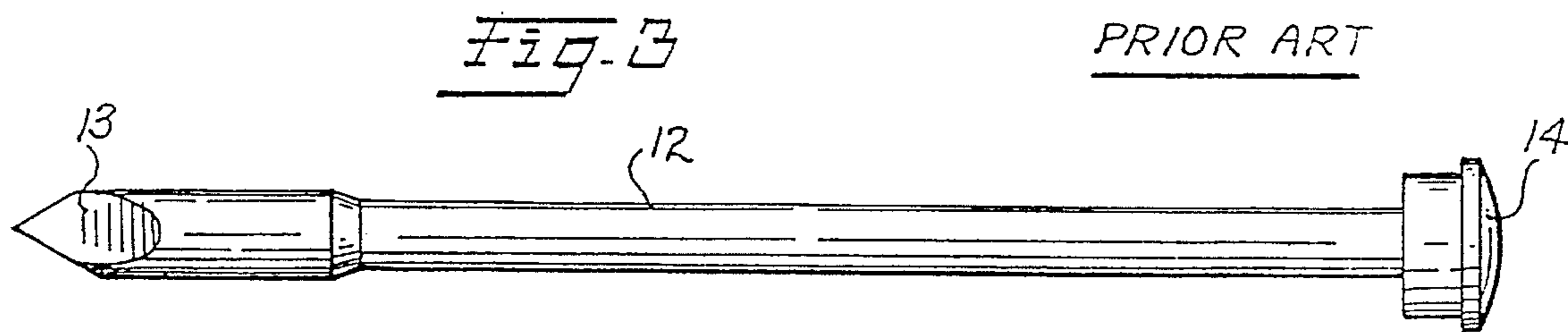
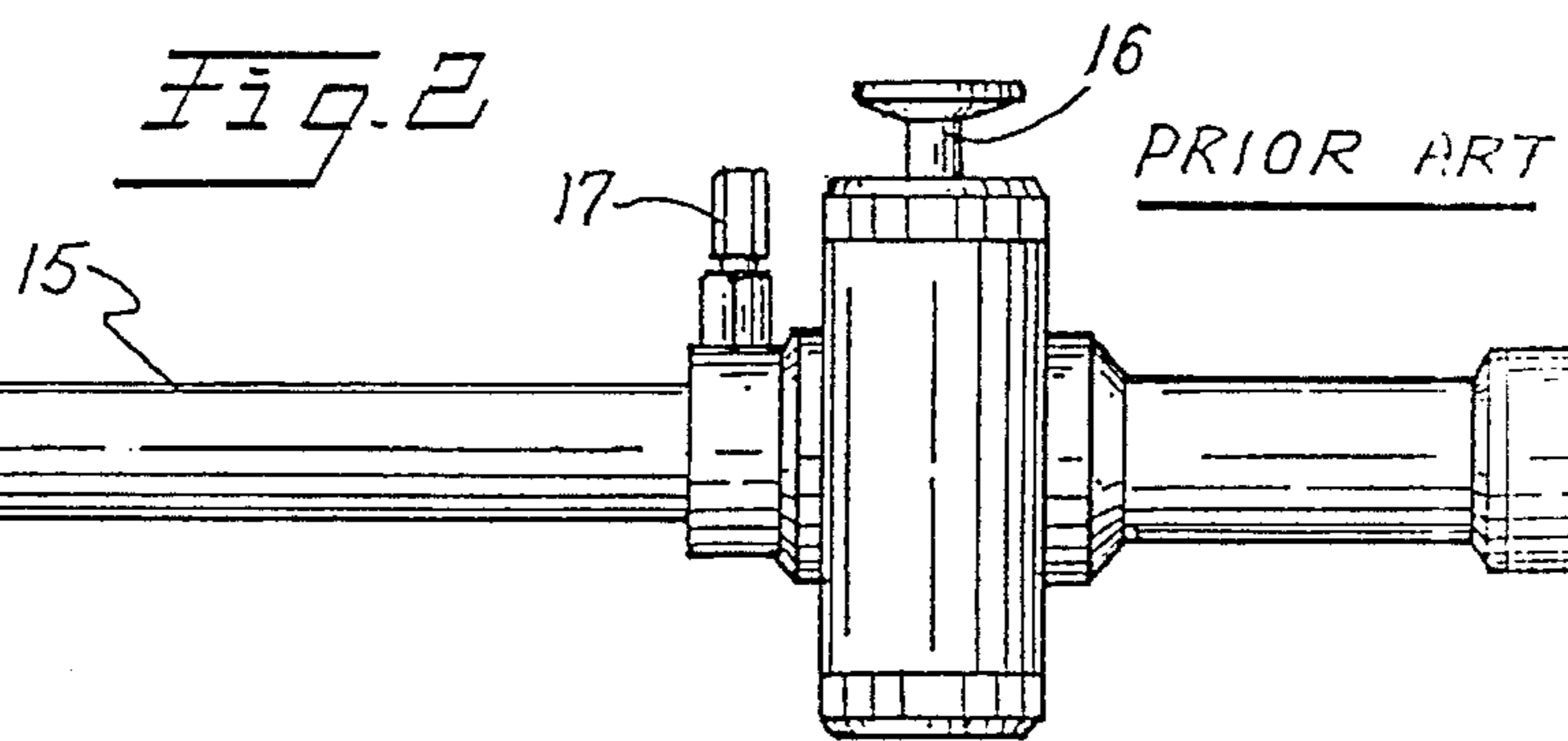
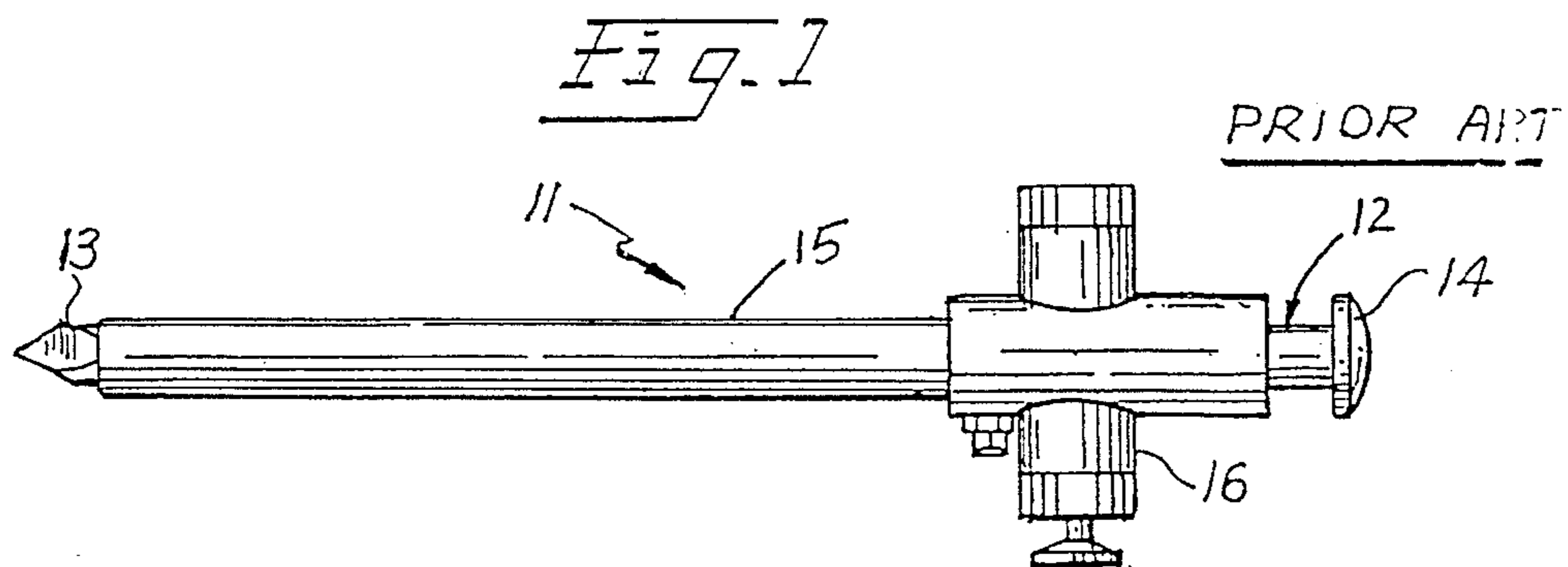


Fig. 5

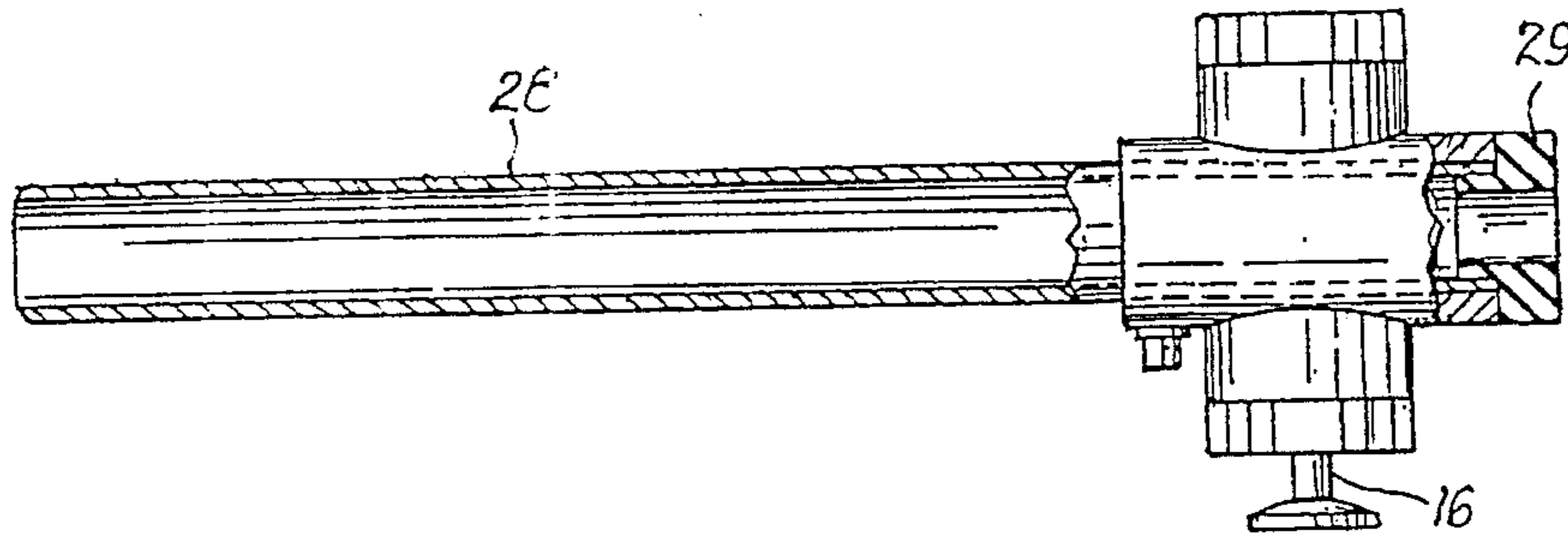


Fig. 6

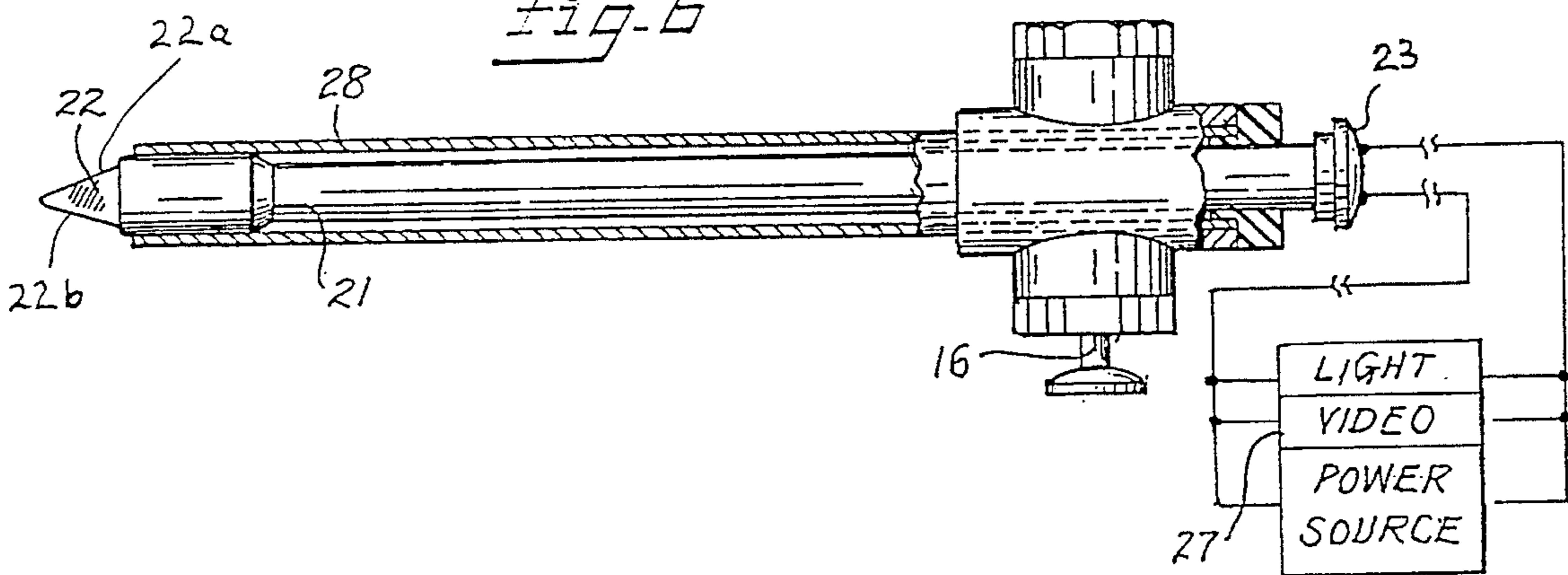
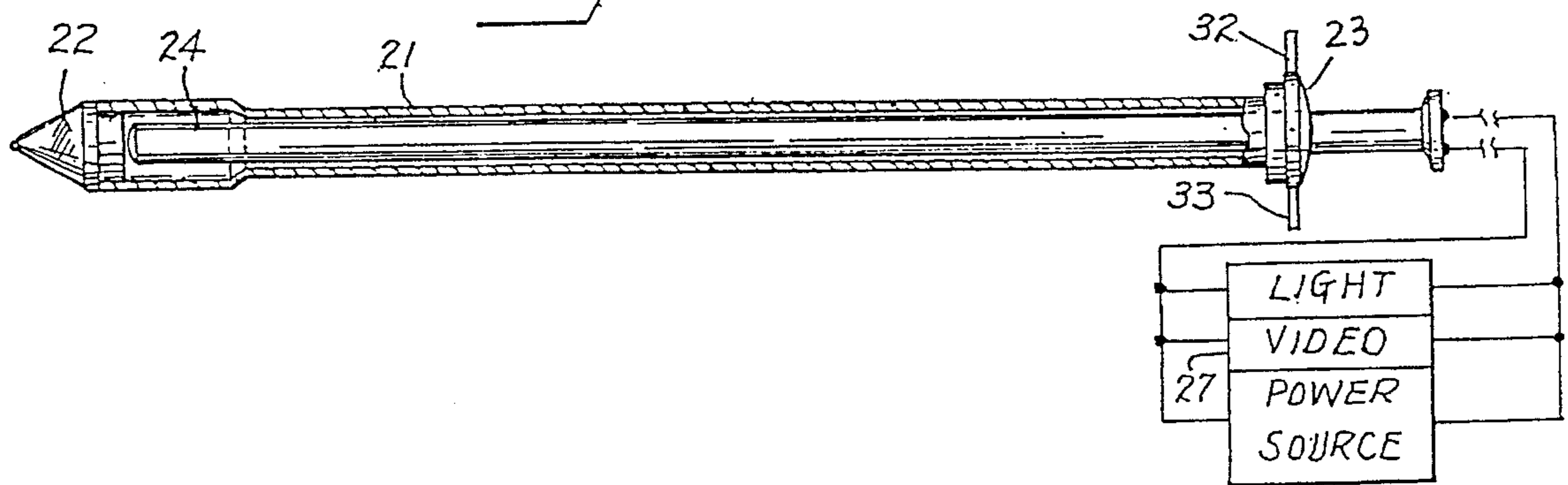


Fig. 7





## VISUALLY DIRECTED TROCAR AND METHOD

### TECHNICAL FIELD

This invention relates to the field of operative and diagnostic laparoscopic surgical procedures and in particular to a new and improved visually directed trocar laparoscopic instrument and method of use for conducting such procedures.

### BACKGROUND OF INVENTION

Operative and diagnostic laparoscopy is the most commonly performed surgical procedure in the United States today. Therefore, any complication associated with this procedure poses a major public health concern.

Conventional known laparoscopic procedures usually are carried out as follows:

1. An instrument known as the Veress needle is blindly inserted through the navel into the abdominal cavity of a patient.
2. Carbon dioxide is delivered blindly through the Veress needle into the abdomen.
3. A laparoscopy trocar assembly comprised by a trocar and trocar sleeve is blindly inserted through the navel into and through the abdominal wall of the abdominal cavity.
4. The trocar is withdrawn from the trocar sleeve and a light telescope with light source placed in the sleeve thus making visualization of the interior of the cavity possible.
5. Once clear visualization is established a variety of surgical procedures can be carried out safely through the central opening in the trocar sleeve with remotely operable surgical instruments in a conventional known manner.

There are several reports in the medical literature that the first two steps of a laparoscopic procedure as outlined above can be omitted, and the laparoscopic trocar assembly be directly inserted blindly into the abdominal cavity. Results of these papers indicate that complications can still be expected since the entry through the abdominal cavity wall into the abdominal cavity remains blind.

### SUMMARY OF INVENTION

It is therefore a primary purpose of this invention to make available a new and improved, visually directed, laparoscopic instrument which allows the laparoscopic surgeon to enter the abdominal or other cavity of a patient under direct vision. This visually directed laparoscopic procedure will eliminate most if not all major and minor complications associated with the blind invasive surgical technique presently employed in laparoscopic procedures as described above.

In practicing the invention a new and improved laparoscopic instrument is provided with an elongated, hollow trocar having a tipped end of pyramidal or the like or conical configuration suitable for insertion through layers of human skin and flesh forming the walls of a cavity with the tipped end being fabricated from light transparent material. The inclined edges of the pyramidal configuration each form a piercing edge. The tipped end of light transparent material preferably is shaped to form a light transmission and imaging element for projecting light outwardly into an abdominal or other cavity of a patient, and for receiving back and

directing light images onto a suitable light image receptor of a conventional miniaturized light telescope designed for surgical purposes. Each piercing edge of the pyramidal configuration cooperates with the light transmission and imaging element to pierce human flesh. The hollow trocar is open at one end and has a central passageway formed therein of sufficient diameter to permit detachable slidable insertion of the elements of a miniaturized light telescope together with essential power supply conductors for energizing the light source and light receptors such as a bundle of fiber optic light coupling elements for deriving and providing back light images usable for laparoscopic diagnostic procedures even while the trocar is being surgically inserted through the navel and is penetrating through the layers of skin and abdominal wall of a patient and on into the abdominal cavity. The open end permits removal of the components inserted into the hollow trocar.

In preferred embodiments of the invention, the laparoscopic instrument includes a hollow tubular trocar sleeve that surrounds and encloses the trocar for a substantial portion of its length to form a combined trocar and sleeve assembly. The trocar is slidable lengthwise relative to the trocar sleeve whereby the trocar can be removed after visually controlled physical placement of the trocar and sleeve assembly into the abdominal wall of a patient's abdominal cavity at a desired location and to a desired depth. The trocar then can be replaced with a somewhat large fiber optic light telescope and video imaging system, and other remotely manipulatable surgical instrument inserted through the central opening of the trocar sleeve in a conventional known manner.

The invention makes available a new and improved laparoscopic procedure comprising mounting a miniaturized light telescope with light source together with suitable miniaturized power supply conductors, and fiber optic coupling and light receptor elements in the hollow trocar prior to starting the laparoscopic procedure. The light telescope then is energized from an electric power source and the output of the light receptors supplied to a video display. Following this setup, the tipped and lighted end of the trocar is placed at a point, such as the navel, on a patient's abdomen to be penetrated while observing such placement on the video display. The lighted trocar then is surgically inserted by being pressed slowly and carefully into and through the walls of the patient's abdomen while observing the progress of the trocar assembly as it travels into and through the wall of the abdominal or other cavity. During this process, the operator, by properly controlling orientation and progress of the trocar tip, can assure that the trocar does not penetrate into the abdominal cavity at a place or for a distance where it might injure any blood vessels within the abdominal cavity walls or internal organs within the abdominal cavity.

### BRIEF DESCRIPTION OF DRAWINGS

These and other objects, features and many of the attendant advantages of this invention will be appreciated more readily as the same becomes better understood from a reading of the following detailed description, when considered in connection with the accompanying drawings, wherein like parts in each of the several figures are identified by the same reference characters, and wherein:

FIG. 1 is a side elevational view of a known, combined trocar and sleeve assembly with trumpet valve and stopcock components constructed according to the prior art;

FIG. 2 is a side elevational view of a known trocar sleeve having a different trumpet valve construction from the



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assembly shown in FIG. 1 and built according to the prior art;

FIG. 3 is a side elevational view of a known trocar design suitable for use with the sleeve shown in FIG. 2 and built according to the prior art;

FIG. 4 is a longitudinal sectional view of a new and improved trocar having a transparent tipped end constructed according to the invention;

FIG. 5 is a longitudinal view of a hollow trocar sleeve suitable for use with the new and improved trocar shown in FIG. 4;

FIG. 6 is a longitudinal sectional view of a new and improved combined hollow trocar and sleeve assembly employing the elements of FIGS. 4 and 5, and constructed in accordance with the invention; and

FIG. 7 is a longitudinal sectional view of an alternative form of a new and improved hollow trocar having extra exterior handles constructed according to the invention.

#### BEST MODE OF PRACTICING THE INVENTION

As noted earlier in the brief description of the drawings, FIGS. 1, 2 and 3 of the drawings illustrate a prior art, known trocar and sleeve assembly now being used by the medical profession in performing laparoscopic procedures such as laparoscopic cholecystectomies. Other similar laparoscopic procedures can be performed using the instrument. In these drawings, FIG. 1 is an elevational side view of a known combined trocar and trocar sleeve assembly 11 comprised by an elongated, solid, stainless steel trocar 12, best seen in FIG. 3, and a hollow, tubular trocar sleeve 15 shown in FIG. 2. Trocar 12 includes a pointed tipped end 13, which may be either pyramidal or conical in configuration, and is sufficiently sharp to be able to penetrate and be physically pressed through the navel, layers of skin and abdominal walls of a patient in order to provide access to the interior of the abdominal cavity. Trocar 12 is a solid rod of appropriate diameter, for example of from 6 to 9 millimeters in diameter, and terminates in a push cap 14 that facilitates surgical insertion of the stiff elongated rod 12 into and through the navel of a patient by pushing on cap 14.

The trocar 12 is physically supported within the trocar sleeve 15 shown in FIG. 2 of the drawings. Trocar sleeve 15 is a cylindrical hollow tube fabricated from biologically compatible material, such as stainless steel. Sleeve 15 has a central opening into which the trocar 12 fits in a relatively tight manner, but is sufficiently loose to allow trocar 12 to be slid lengthwise relative to the sleeve 15 and withdrawn. Trocar sleeve 15 in most applications also includes at least one trumpet valve 16 as shown in both FIGS. 1 and 2 as well as one or more insufflation stopcocks shown at 17 in FIG. 2. These elements all are of known construction and operation and need not be described in detail with respect to the present invention. In use the assembled trocar and sleeve appear as shown at 11 in FIG. 1 of the drawings.

As described earlier in the specification, conventional laparoscopic procedure is carried out by first blindly inserting a Veress (not shown) through the navel into the abdominal cavity of the patient. Carbon dioxide gas then is delivered blindly through the Veress needle into the abdomen in an effort to draw the skin of the abdomen on which the navel is disposed away from any organs resting internally within the abdominal cavity and to improve visualization within the cavity. It is at this point that the laparoscopic trocar and

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sleeve assembly 11 is blindly inserted through the navel into the abdominal cavity.

After insertion of the trocar and sleeve assembly 11, the trocar 12 is withdrawn from the trocar sleeve 15 leaving the sleeve with its appended elements such as the trumpet valve 16 and insufflation stopcock 17 extending into the abdominal cavity. A light telescope with a miniaturized light source of conventional commercially available construction is inserted through the central opening of the trocar sleeve 15 to establish visualization of the intra-abdominal organs. Once clear visualization is established, a variety of surgical procedures can be carried out safely through the use of remotely operable surgical instruments inserted into the interior of the abdominal cavity through the central passage-way in the trocar sleeve 15 in a known manner. Upon completion of the procedures, all instruments including the light telescope are withdrawn along with the trocar sleeve and the opening through which they were inserted is sewn up.

It is believed apparent that the step of introducing the trocar and sleeve assembly into the abdominal cavity using conventional known techniques, is a blind procedure and frequently causes injury to blood vessels in the walls of the abdominal cavity and organs located within the abdominal cavity close to the point of entry.

In order to avoid possible injury to the blood vessels and/or internal organs, the present invention was devised and is illustrated in FIGS. 4, 5 and 6 of the drawings together with FIG. 7 which shows an alternative construction of the trocar according to the invention.

FIG. 4 is a longitudinal sectional view taken along the longitudinal axis of an elongated, cylindrically-shaped trocar having a hollow tubular body 21 fabricated from an inflexible material (such as stainless steel) that is compatible with human flesh. Trocar 21 has a tipped end 22 that is sufficiently sharp that it can be surgically inserted through layers of skin and human flesh by physically pressing on a push cap 23 secured to the opposite end of the trocar. Tipped end 22 is fabricated from light transparent material such as glass or a space-age plastic and is shaped to form a light transmission and imaging element for projecting light outwardly into an abdominal or other cavity of a patient and for directing light images received back onto a suitable light image receptor 24. Tipped end 22 also has a substantially solid piercing point, as shown in FIG. 4, which can be of pyramidal or conical configuration. As shown in FIGS. 4 and 7, for example, a tapered portion of the tipped end 22 projects from the tubular body 21 and a non-tapered portion of the tipped end 22 is recessed in the tubular body 21. The pyramidal configuration of the tipped end 22 includes tapered edge portions such as 22a and 22b (FIG. 6) that each function as a piercing edge when the tipped end 22 is inserted through layers of skin and human flesh.

Light image receptor 24 is part of a commercially available, miniaturized, medical light telescope for surgical use and is not part of this invention. Receptor 24 may comprise a plurality of light receiving input ends of a bundle of fiber optic light coupling elements (not shown) or alternatively a semiconductor light to electric signal transducer. Trocar 21 has a central opening 25 which is of sufficient diameter to accommodate passage of the elements of the miniaturized light telescope such as a light source 26 comprised by a bundle of fiber optic elements, a semiconductor laser or a light bulb together with essential power supply conductors and/or fiber optic light coupling elements (not shown). These elements serve to energize light source 26 and light



receptors **24** (or transducers if required) together with fiber optical or electric signal coupling elements for deriving and supplying video signals to a video camera **27**, comprising a part of the light telescope system. The video camera **27** excites a suitable video monitor (not shown) for producing video images usable for diagnostic and surgical purposes even while the trocar is being surgically inserted into and is penetrating the layers of skin on the navel prior to proceeding into the abdominal cavity.

Trocar **21** shown in FIG. 4 is designed for use with a trocar sleeve **28** shown in FIG. 5. Trocar sleeve **28** comprises an elongated hollow tubular body of stainless steel or other similar material having an open end through which the tipped transparent end **22** of trocar **21** projects and a rubber sealing cap **29** on the opposite end. Preferably a trumpet valve **16** and insufflation stopcock, such as **17** shown in FIG. 2, are included on the hollow trocar sleeve **28**. If desired, the trocar sleeve **15** shown in FIG. 2 and trocar sleeve **28** in FIG. 5 can be made to be interchangeable.

Trocar sleeve **28** is designed to physically surround and enclose trocar **21** for a substantial portion of its length to form a combined trocar and sleeve assembly shown in FIG. 6 of the drawings. The trocar **21** is slidable lengthwise relative to trocar sleeve **28** so that the trocar can be removed after visual surgical insertion of the trocar **21** and sleeve **28** assembly into the abdominal cavity of a patient at a desired location and to a desired depth. After removal of trocar **21**, it is replaced with a suitable known fiber optic light source and video imaging system (not shown) and supplemented with other remotely manipulatable surgical instruments (not shown) which can be inserted through the central opening of the trocar sleeve **28** in a conventional, known manner.

FIG. 7 illustrates an alternative design of the trocar **21** wherein suitable handles shown at **32** and **33** are provided on opposite sides of the elongated tubular body of the trocar **21** at the end opposite transparent tip end **22**. In all other respects, the trocar of FIG. 7 is similar to that described with relation to FIG. 4. Surgical insertion of the trocar **21** of FIG. 7 and trocar sleeve **28** in assembled relation as depicted by FIG. 6, through the navel of a patient can be better accomplished and more easily guided using the handles **32** and **33** while visually observing the progress of the trocar through the layers of skin and abdominal walls of a patient. By observing the pre-imminent entry of the trocar assembly into the abdominal cavity under conditions where the position of blood vessels in the walls of the abdominal cavity and internal organs located within the abdominal cavity can be observed, prior to thrusting the trocar all the way into the cavity, injury to the blood vessels and internal organs can be avoided.

In conducting a laparoscopic procedure employing the novel, hollow, laparoscopic trocar **21** with a tipped end **22** fabricated from light transparent material shaped to form a light transmission and receiving element, the procedure is commenced by activating the miniaturized light telescope including the light source and suitable miniaturized light receptors, power supply conductors and fiber optic couplings provided in the assembled hollow trocar and sleeve, while using the trocar of either FIG. 4 or FIG. 7, prior to starting the procedure. After the light source is activated, any output from the light receptors **24** is supplied to a video display console (not shown) via video receiver **27**. The tipped and lighted end of the trocar **21** then is placed at the point on the patient's abdomen (such as the navel) to be penetrated while observing such placement on the video display. The trocar and sleeve assembly then is pushed slowly into and through the layers of skin and support flesh

of the patient's navel while observing the progress of the trocar assembly on the video display while it travels into and through the navel. During this process, the positioning of the trocar can be adjusted by the laparoscopic surgeon, if necessary, by manipulation of the push cap **23** and/or side handles **32** and **33**, to assure that the trocar does not penetrate into the abdominal cavity at a place or for a distance where it might penetrate and injure blood vessels in the walls of the cavity or internal organs within the abdominal cavity.

In the above recited procedure, the combined assembly of trocar **21** and trocar sleeve **28** are inserted together with the light source and video display components of the miniaturized light telescope contained therein. After completing the visually directed insertion of the combined trocar and sleeve assembly as described above, the trocar **21** together with its light source and video display components is removed from sleeve **28** which remains implanted in the abdominal cavity. The trocar **21** then is replaced in implanted sleeve **28** with the fiber optic light source and video imaging system of the miniaturized light telescope along with any other assorted remotely manipulatable surgical instruments, as needed, which are inserted through the central opening in the trocar sleeve in a conventional known manner.

#### PRACTICAL APPLICABILITY

This invention provides to the medical profession a new laparoscopic instrument which allows the laparoscopic surgeon to enter the abdominal cavity of a patient under conditions where he can directly, visually follow the progress of the pointed tip of the instrument as it passes through the layers of skin and supporting walls of the abdominal cavity. Hence, prior to entering the abdominal cavity to any great depth, the surgeon can observe whether there are any blood vessels in the supporting walls or internal organs which would be punctured or otherwise damaged if the trocar is allowed to penetrate too deeply at a selected point. The new procedure and instrument will eliminate many major and minor complications associated with the prior known blind invasive laparoscopic surgical techniques employed to implant the laparoscopic trocar and sleeve assembly into the abdominal cavity.

Having described two embodiments of a new and improved laparoscopic instrument and procedure according to the invention, it is believed obvious that other modifications and variations of the invention will be suggested to those skilled in the art in the light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiments of the invention described which are within the full intended scope of the invention as defined by the appended claims.

What is claimed is:

1. A surgical penetration device comprising:
  - a) an inflexible hollow tubular member,
  - b) a light transmission and imaging member formed essentially of transparent material provided at one end of said hollow tubular member to project light and receive light images,
  - c) a piercing edge cooperable with said light transmission and imaging member for piercing human flesh to permit surgical insertion of said light transmission and imaging member through human flesh into a body cavity,
  - d) said light transmission and imaging member being formed separately of said hollow tubular member and affixed to said one end of said hollow tubular member to extend beyond said one end of said hollow tubular



member, said light transmission and imaging member having a portion that is of diminishing cross-sectional magnitude the further distant said portion is from said one end of said hollow tubular member, and

e) an opposite end of said hollow tubular member being open and the open end and the inside space of said hollow tubular member being of a predetermined size to permit detachable slidable insertion of a conventional lighting member and a conventional light image receiving member in the form of a conventional light telescope into the inside space from the open end of the hollow tubular member, and slidable removal of the conventional light telescope from the open end of the hollow tubular member, whereby said light transmission and imaging member is cooperable with said conventional light telescope when said conventional light telescope is inserted in said hollow tubular member.

2. The surgical penetration device as claimed in claim 1 wherein said light transmission and imaging member includes a section that is recessed in the one end of said hollow tubular member.

3. The surgical penetration device as claimed in claim 2 wherein the recessed section of said light transmission and imaging member is substantially circular in cross section.

4. The surgical penetration device as claimed in claim 2 wherein the recessed section is integrally joined to said hollow tubular member at said one end of said hollow tubular member.

5. The surgical penetration device as claimed in claim 1 wherein said light transmission and imaging member is formed of glass.

6. The surgical penetration device as claimed in claim 1 wherein said light transmission and imaging member is formed of plastic.

7. The surgical penetration device as claimed in claim 1 wherein said hollow tubular member has a handle member provided proximate said opposite end of said hollow tubular member to facilitate manipulation of said hollow tubular member.

8. The surgical penetration device as claimed in claim 1, wherein said piercing edge extends axially and transversely of said light transmission and imaging member.

9. The surgical penetration device as claimed in claim 1, wherein said light transmission and imaging member is of pyramidal shape.

10. A method of visualizing insertion of a surgical device through flesh into a body cavity comprising the steps of:

a) providing an inflexible hollow tubular member,

b) forming a light transmission and imaging member essentially of transparent material with a portion that is of diminishing cross-sectional magnitude in a predetermined direction along the light transmission and imaging member,

c) attaching the light transmission and imaging member at one end of the hollow tubular member such that the light transmission and imaging member has the diminishing cross-sectional magnitude the further distant said portion of the light transmission and imaging member is from the one end of the hollow tubular

member, and leaving the opposite end of the hollow tubular member open,

d) providing a piercing edge for cooperation with the light transmission and imaging member to pierce flesh and permit insertion of the light transmission and imaging member through the pierced flesh into a body cavity,

e) slidably locating a conventional lighting member and a conventional light image receiving member in the form of a conventional light telescope in the opening at the opposite end of the hollow tubular member to locate the conventional light telescope proximate said light transmission and imaging member in the interior hollow space of the hollow tubular member to enable light from the conventional light telescope to project outwardly away from said light transmission and imaging member and to permit the conventional light telescope to receive light images that pass from outside said light transmission and imaging member through said light transmission and imaging member while said light transmission and imaging member is being inserted through the flesh into a body cavity, whereby said light transmission and imaging member provides a receivable image for the conventional light telescope of the flesh and body cavity being entered, and

f) keeping the conventional light telescope in the hollow tubular member in a manner that permits slidable removal of the conventional light telescope from the opening at the opposite end of the hollow tubular member when the hollow tubular member is removed from the flesh.

11. The method of claim 10 including slidably locating said hollow tubular member with said light transmission and imaging member in a sleeve and fixing the position of said hollow tubular member relative to the sleeve such that the light transmission and imaging member projects from one end of the sleeve to permit insertion of the sleeve with the light transmission and imaging member through the flesh into a body cavity.

12. The method of claim 10 including monitoring the light images received by the light transmission and imaging member on a video screen while the light transmission and imaging member is being inserted through the flesh into a body cavity to obtain continuous video aided visual imaging of the internal location of the light transmission and imaging member during such insertion.

13. The method of claim 10 including slidably removing the conventional light telescope from the opening at the opposite end of the hollow tubular member to separate the conventional light telescope from the hollow tubular member.

14. The method of claim 11 including slidably removing the hollow tubular member with said light transmission and imaging member from said sleeve, while said sleeve remains inserted through the flesh into a body cavity.

15. The method of claim 10 including forming the light transmission and imaging member with a cutting edge.

16. The method of claim 10 including forming the light transmission and imaging member with a piercing point.